produced interesting results. In spite of the severe problems of drilling in volcanic material, the results to date show that progress is possible and that greater depths could be reached. The present drillhole can be deepened further, but probably not much below the present depth — perhaps 50 m more, at most. Plans are now being developed for a larger drilling operation in the hope of reaching 500 m or more.

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News & Announcements

Early HVO Bulletins Collected, Published

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The volcanology bulletins published since the early 20th century by the Hawaiian Volcano Observatory (HVO) are now available as a three-volume set. In this collection, the contents of *The Volcano Letter* and other early HVO publications are fully indexed for the first time.

The HVO collection, entitled *The Early Serial Publications of the Hawaiian Volcano Observatory*, was inspired by the Smithsonian Institution's 1987 reprint *The Volcano Letter, 1925–1955*. The new work includes an index to *The Volcano Letter* as well as to the other early HVO publications, along with a bibliography. In the preface to the HVO volumes, compilers Darcy Bevens, Taeko Jane Takahashi, and Thomas L. Wright explain that this collection completes the reprinting of the early HVO serial publications. Each volume is separately paginated and indexed, and the collection spans works from 1913 to 1955.

The collection became available May 1988. Inquiries for orders can be directed to Kathy English, Business Manager, Hawaiian Natural History Association, Ltd., PO Box 74, Hawaii National Park, HI 96718. Questions regarding the contents of the volumes can be directed to Thomas L. Wright, Hawaii Volcano Observatory, PO Box 51, Hawaii National Park, HI 96718.

This item was contributed by T. Jane Takahashi, *Hawaii Volcano Observatory, Hawaii National Park.*

Information Report

Flow in an Experimental Micro–Magma Chamber

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The chemical evolution and eruptive behavior of magmas may be controlled largely by convective processes within magma chambers. According to a recent National Research Council Report [*Committee on Physics and Chemistry of Earth Materials*, 1987], "the style of convection itself, whether it is turbulent, laminar, large-scale, of multiple scales, tiered, or localized and intermittent, is very much at question." In the U.S. National Report to the International Union of Geodesy and Geophysics, *Marsh* [1987] reviewed recent theoretical and experimental developments related to the style of convection in magma chambers, noting both significant quantitative advances and also the many remaining uncertainties. With regard to double-diffusive convection, he stated "as ever, the critical question concerns whether or not actual magma chambers convect in this style." Similarly, *Spera et al.* [1986], in discussion of double-diffusive convection, cautioned against "applying results from saltwater tanks to magma chambers."

Experimental silicate melts are commonly considered inappropriate for examining convective processes in magma chambers because of the very small length scales necessitated by laboratory studies (millimeters versus meters to kilometers in actual magma chambers). We are not aware of any experimental studies on convection in granitic melts with dissolved H_2O under pressure. Results suggesting the operation of compositional convection accompanying dissolution of a silical glass rod in a picritic melt at 1 atm led *Donaldson and Hamilton* [1987] to the conclusion "that there is a role for experimental petrology in the investigation of magmatic fluid processes." Here we present preliminary results suggesting that convective processes in hydrous silicate melts at elevated pressures may also be amenable to experimental study.

The cover photograph shows the result of an experiment conducted at 10 kbar and 950°C for 30 hours. Flow lines in the hydrous granite melt (left) are revealed by trails of graphite particles (black). The graphite was produced by reduction of the small amount of CO_2 present in the experiment's starting materials. The photograph clearly shows organized flow: The melted granite flows horizontally from left to right through the center of the charge and then turns to flow both up and down toward the margins of the capsule. Additional experiments have confirmed that the flow features are reproducible.

The run illustrated is one of a series of experiments designed to explore the effects of contamination of hydrous silicic magmas by mafic and ultramafic rocks near the crust-mantle boundary. Equal masses of powdered granite and serpentized amphibole peridotite (dark material on far right of the cover photograph) were packed into a small gold capsule so that the two materials were in contact at a sharp boundary. The experiment was run with the capsule mounted in a piston cylinder apparatus in the same orientation as is shown in the photograph. During the experiment, breakdown of serpentine in the peridotite starting material (~6 wt % H_2O) releases water and causes progressive melting of the granite. Shorter duration experiments show that melting begins next to the granite-peridotite boundary; increasing run duration results in formation of a progressively wider band of granitic glass, grading into a zone of crystals and liquid at the distal end of the capsule (left in the photograph). Graphite trails and entrained rounded crystals defining flow patterns similar to those in the photograph can be seen emanating from this crystal/liquid region in some experiments.

Wide beam electron microbe analyses of the granitic melt portion of the charge show that it is homogeneous and almost identical in composition to the starting granite. The most notable change is a slight enrichment in MgO from 0.1 to 0.5 wt %. The differences between analytical totals and 100% indicate that the granitic melt contains 7 ± 1 wt % dissolved H_2O. Calculations of the density of the granitic glass [*Kushiro*, 1984], based on microprobe analyses spread throughout the charge, show no significant spatial variations, and the total range is within 0.05 g/cm^3. The viscosity of the melt with 6–8 wt % H_2O at 950°C is calculated to be 3000–4000 poise [*Shaw*, 1972]. Temperature gradients in the charge are small and less than ~5°C.

The results shown in the cover photograph confirm that flow in hydrous granitic melt is amenable to experimental investigation. There are many mechanisms that may have been involved in driving the flow, including surface tension effects, small variations in the melt's water content, a small horizontal temperature gradient, and volume changes caused by crystallization or dissolution. Theoretical considerations suggest that a small horizontal temperature gradient could produce the observed flow. Small variations in water content could also be important in promoting flow of granitic melt by causing significant variations in melt density. We are presently exploring these and other possible driving forces.

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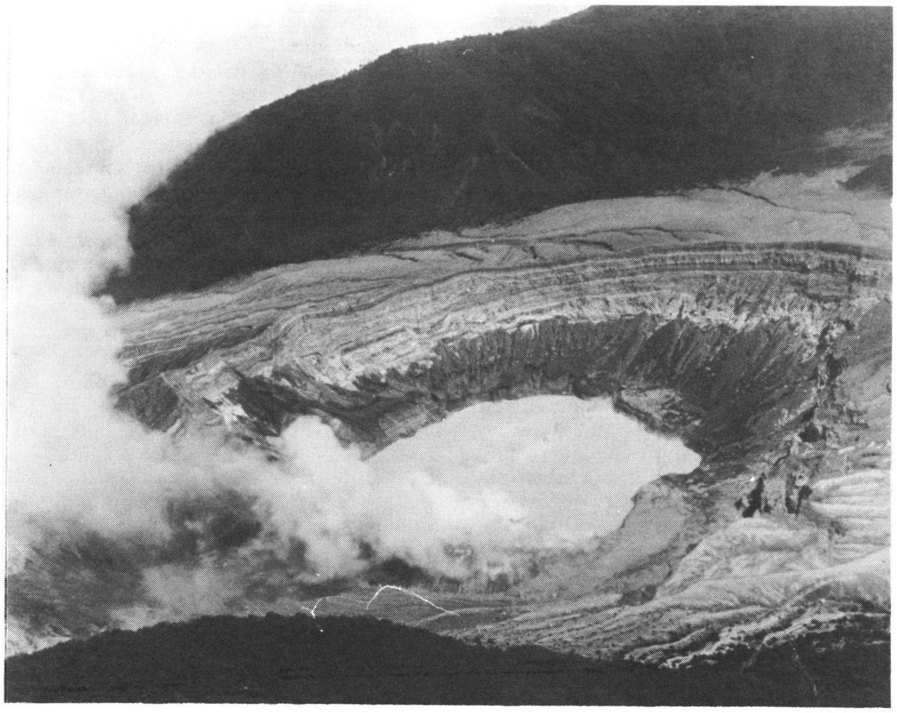

Fig. 1. Oblique aerial view of the crater lake of Poás Volcano, Costa Rica. The view is from the south; the lake is about 300 m in diameter. Photograph courtesy of the U.S. National Aeronautics and Space Administration/Wallops Flight Center, Wallops Island, Va.

Temperature Profiles From Poás Crater Lake

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In 1984, we took part in an expedition to measure the temperature field and bathymetry of the acid lake (Figure 1) that has formed in the crater of Poás volcano, Costa Rica, since its last eruption in 1953. Obtaining these data was the first step in a long-range study planned by researchers at the Center for Geophysical Research, University of Costa Rica (San José, Costa Rica), and the College of Oceanography, Oregon State University (Corvallis). The study will eventually consider all aspects of fluid behavior in a volcanic lake that is heated or otherwise convectively driven by energy injected at the lake bottom.

Evidence of convection is clearly visible on the surface of the Poás lake most of the time. Fumarole activity has been continuous since 1953. Phreatic explosions are quite frequent, varying from weak to strong, and the height of the ejected column varies from 1 to more than 500 m. One immediately useful result of the research would be an estimate of the heat transfer from sources within the conduit to the overlying water column. As far as geophysical fluid behavior goes, we are interested in the turbulent and diffusive processes by which heat and chemical species are transferred. We are especially interested in the impact on the density stratification of the density changes that occur as particulates settle downward through the fluid column. The stratification would otherwise be controlled by the turbulent and diffusive processes driven by thermochemical factors.

The lake is ~300 m in diameter, with sheer vertical walls in most places. Periodic samples of its surface waters during 1980–1981 showed temperatures ranging from 22 to 49°C, a strong acidity with $pH < 1$, and average sulfate concentrations of ~53,000 ppm [*Casertano et al.*, 1985]. The water is mainly a hot sulfuric acid solution, diluted from time to time by rainwater and enriched by periodic phreatic explosions. A dense vapor rich in sulfuric acid usually covers the water's surface. This gas cloud forced us to wear gas masks constantly when we were working near the water's edge.

There are no prior measurements of the lake's interior thermal structure or its bathymetry. We used a radio-controlled catamaran hull with airscrew propulsion to carry and launch disposable thermal probes (modified T-7 Sippican Corporation probes that are used in ocean sampling). The probe pays out a pair of wires from an internal bobbin, so the resistance of its thermistor sensor was recorded ashore on a paper chart and later converted into equivalent temperatures. Prior laboratory checks in heated samples of Poás water showed no measurable change in sensor or wire performance over 10 minutes, which is a much longer time than that taken up by delivery, launch, and fall of probes in the field.

We first sampled the horizontal temperature field over the northern half of the lake surface, in a triangular track that was traversed in 8 minutes. From launch to return the probe measured a change of only 1.4°C, most of which represented a gradual warming of surface water toward the lake center. This was expected because active fumaroles occur in the south of the crater, and the lake surface near the south shore showed patches of turbulence that were evidence of vertical convection. Surface temperature taken with a glass thermometer at the launch site on the northern shore was 48°C.

Four vertical drops were made before we lost control of the boat in the vapor cloud and a light acid rain shower. Position control was poor because of the visibility factor; we "navigated" by the sound of the airscrew motor. Three of the vertical profiles produced useful data, with results described below.

Bathymetry and Bottom Temperatures

Water depth in the central portion of the lake was about 50 m. This result is based on fall times of 23, 25, and 26.5 s to a clearly distinguishable step function in each recorded trace, which we interpret as the point of